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Early math interest and the development of math skills : an understudied relationship.

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EARLY MATH INTEREST AND THE DEVELOPMENT OF MATH SKILLS: AN UNDERSTUDIED RELATIONSHIP

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DEDICATION

To my family, and to Dan.

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First and foremost, thank you to the children, teachers and administrators at Head Start, without whom this project would not have been possible.

I am extremely lucky to have exceptional people in my life. These individuals have challenged and supported, broadened my perspective, and been there in times of distress and happiness. To them, I owe many of the joys I have experienced during my years of graduate training.

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ABSTRACT

EARLY MATH INTEREST AND THE DEVELOPMENT OF MATH SKILLS:
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Although mathematical skills are important to economic success in this society, U. S. students routinely perform below international standards of math achievement. Given such findings, there is a pressing need to understand factors that contribute to individual and group weakness in mathematics before such difficulties become entrenched. By studying preschool children with a longitudinal approach, the current study aimed to improve understanding of math development by investigating the unfolding relationship between math interest and achievement. Based on research with older children, it was expected that math interest and skill would be both concurrently related and predictive of one another over time. Additionally, research from the self-efficacy literature suggests that a child's conception of his or her math ability would be related to both the child's math interest and actual skill. Using the TEMA-2 as an assessment of skill and a multimodal approach to measuring interest, this study explored the measurement of math interest in young children. Gender and ethnic differences were found in select teacher measurements of interest, though none were found on observed or child-reported interest. Concurrent relationships were found between the different measures of interest and math

ability. Even when controlling for initial skill or interest, skill was predictive of later observational ratings of math interest, and both observational and teacher measurements of interest were predictive of later skill. Because the assessment of self-efficacy demonstrated poor psychometric properties, further analyses were not conducted.

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CHAPTER 1

INTRODUCTION

Adequate mathematical skills are an important component to economic success in this society, acting as a "critical filter" to many scientific and technological careers (Betz & Hackett, 1983). However, in the last several decades, U. S. students have routinely performed below international standards of mathematics achievement (Geary, 1996). For example, skill differences between American children and Chinese children are apparent as early as kindergarten (Geary, Bow-Thomas, Liu, & Siegler, 1996). Elementary and high school mathematics weaknesses impact universities and graduate schools, as science and mathematics programs struggle to find students to enroll, and employers struggle to find adequately trained applicants (Eccles, 1997). Technological advancements and demands of the last few decades have led prominent thinkers in the field to express concern about the ability of U. S. students to meet future challenges (Clark, 1988). Concern about children's mathematical development has recently prompted the National Council of Teachers of Mathematics to recommend that math instruction begin in preschool (National Council of Teachers of Mathematics, 2000). Despite consensus that early math experiences are critical, not enough is known about the emergent stages of math development.

In addition to general concerns about math development, certain groups are especially likely to demonstrate inadequate math achievement and/or disinterest in science and mathematics careers. Women and low-income groups are especially absent from technological fields (Ascher, 1984; Bailey, 1990; Eccles, 1997). A report from the National Science Foundation in 1996 stated that women compose only 8% of engineers and 20% of physical scientists (National Science Foundation, 1996). It does not seem that this gender difference is due to lower ability, but rather to other factors such as internalized belief systems (Hyde, Fennema, & Lamon, 1990). Low-SES groups are vulnerable to poor math skills attainment (Rech & Stevens, 1996); because minority groups are disproportionately affected by poverty, they are at risk for poor math achievement.

Given such findings, there is a pressing need to understand factors that contribute to individual and group weakness in mathematics. Previous research has covered factors such as spatial cognition (Geary, 1996), home environments and maternal intelligence (Crane, 1996), health issues (O'Brien Caughy, 1996), and expectations of success (Bandura, 1986; Eccles, 1983). Brief longitudinal studies suggest that general school attitude is related to the math skills of young, disadvantaged children (Reynolds, 1989; Stipek & Ryan, 1997), and researchers have called for increased focus on motivational factors in models of achievement (Reynolds, 1989; Wigfield et al., 1997). It has been shown that complex beliefs, attitudes, values and emotions can play important roles in children attaining a strong foundation in mathematics (Eccles, 1983; Efklides, Papadaki, Papantonious, & Kiosseoglou, 1997; Lester, Garofalo, & Kroll, 1989; Ma, 1997; McLeod, 1994; Yasutake & Tanis, 1995). Additionally, studies that address such motivational variables often include measures of student scholastic interest, although they usually collapse the construct within a larger motivational framework (Eccles, 1983; Eccles, Wigfield, Harold, & Blumenfeld, 1993; Wigfield et al., 1997).

Previous research on the role of attitudes and motivation in the development of math ability suggests that a child's interest in the material to be learned aids his or her mastery of the information. Czikszentmihalyi (1990) explains one reason for the impact of interest on achievement by stating "if intrigued by the opportunities of the domain, students will make sure to develop the skills they need to operate within it" (p. 126). Hidi, Renninger, & Krapp's (1992) review of interest research led them to conclude that interest has "a profound effect on cognitive functioning and the facilitation of learning" (p. 565). Despite initial indications of the importance of interest to learning, it is a relatively unexamined concept. The growing evidence of the importance of interest has led to a call for increased empirical investigation of the contribution of interest to academic success (Lonigan, Anthony, Arnold, & Whitehurst, 1994; O'Flahavan et al., 1992; National Council of Teachers of Mathematics, 1989; Scarborough & Dobrich, 1994; Schiefele, 1991; Skinner, Wellborn, & Connell, 1990; Wentzel, Weinberger, Ford, & Feldman, 1990), including specific attention to the potential importance of math interest to math achievement (Czikszentmihalyi, Rathunde, & Whalen, 1993; Turner et al., 1998).

The theoretical importance of children's academic interests is not newly recognized. Educational philosopher John Dewey (1913) was a strong proponent for the significance of academic interest when considering learning and achievement. A poll of 350 educators indicated that creating interest was the most important of 84 problems faced by the education system (O'Flahavan et al., 1992). Despite this consensus, math interest is a scantily researched concept (Hidi, 1990), and defining interest in a research context is still in its nascent stages (Renninger, Hidi, & Krapp, 1992). Though interest is considered a contributor to intrinsic motivation (Hidi, 1990), it also has distinct characteristics (Schiefele, 1991). Schiefele (1991) defines interest as "a content-specific concept...(that) is always related to specific topics, tasks or activities" (p. 301). He identifies enjoyment and involvement as most characteristic of interest, and others have sought to measure student interest by assessing "focused, prolonged, relatively effortless attention, all of which is accompanied by feelings of pleasure and concentration" (Krapp, Hidi, & Renninger, 1992, p. 5). More recently, Ainley, Hidi and Berndorff (2002) emphasize the construct of persistence as an important component of interest. This conceptualization of individual interest defines the parameters within which relevant research is being conducted.

Several studies have attempted to understand the mechanisms by which interest affects learning. Amount of time spent on a task (Ortiz, 1997) and level of arousal (Middleton, 1992) seem to be two ways that interest might increase learning, and research on reading interest indicates that increased interest also causes a deeper level of information processing (Hidi, 1990; Schiefele, 1999). Interest affects the manner in which an individual comprehends information, such that people who are interested in a task incorporate information in a more meaningful and lasting manner.

The relationship between interest and achievement is well documented in older children and adults (e.g., see meta-analysis of Schiefele, Krapp, & Winteler, 1992). Specifically in terms of math achievement in older children, interest significantly contributes to prediction of grades and course level (Köhler, Baumert, & Schnabel, 2001; Schiefele & Czikszentmihalyi, 1995; Singh, Granville & Dika, 2002). Renninger (1992) demonstrated a relationship in mid-elementary aged children. Though the previous studies with older children focused specifically on the relationship between math interest and ability, Stevenson and Newman (1986) demonstrated that children's cognitive skills in kindergarten predicted attitudes toward mathematics in 10^{th} grade, and Stannard, Wolfgang, Jones and Phelps (2001) found that construction-oriented play in preschool predicted math standardized test scores in 7^{th} grade and high school.

The aforementioned literature suggests that math interest might be an important contributor to the development of math skills in preschool children. The National Council of Teachers of Mathematics has identified "enhancing children's natural interest in mathematics" as a primary component of high-quality mathematics curriculums for young children (National Council of Teachers of Mathematics, 2002). While there is no research to date on the specific relationship between math interest and achievement in preschoolers, reading research with this population demonstrates that early reading interest can be an important predictor of later literacy skills (Lonigan et al., 1994; Manning & Manning, 1984; Thomas, 1984; Wells, 1985, Van Krayernood & Schneider, 1999). Preschoolers who rarely chose books as a method of entertainment were poorer readers in second grade than peers who chose to read daily (Scarborough, Donovich, & Hager, 1991), and preschoolers who enjoyed reading in the fall demonstrated higher performance on a spring reading task than their less interested peers (Stipek & Ryan, 1997).

This reading research with preschool children, combined with the math interest research with older children, suggests that math interest in young children likely influences the development of math ability and that ability might influence interest. Understanding more about how math interest and math ability affect one another would be an important addition to the math achievement literature. Ma (1997) suggests that the relationship between attitudes towards math and achievement in math is reciprocal, with each variable strengthening the effect of the other. In this model, people who have high math ability show more interest in math because they find it enjoyable to engage in activities in which they can be successful. This heightened interest means that individuals spend more time pursuing math activities, and perhaps learn math on a deeper level of processing, which in turn improves ability. Though this is framed as a positive cycle, it could function in a negative loop in individuals who are low on interest or ability. A recent study with first grade children assessed three times during the course of the year indicated some support for a cyclical relationship when measuring task-avoidant or task-focused behavior in relation to reading ability: children who avoided reading demonstrated a decrease in skills, and children who were poor readers avoided reading activities. However, in terms of math, support was only found for one direction of the cycle: students who demonstrated poor math skills were task avoidant during math activities (Onatsu-Arvilommi & Nurmi, 2000).

Another construct that might be related to interest, but has thus far been little studied, is children's beliefs about their ability in a given area. Deci (1992) argues that interest is a core component of the self. Contexts that produce changes in interest will similarly influence changes in a sense of self. One such concept, self-efficacy, is a domain focused belief about one's ability in relation to specific items (Marsh & Craven, 1997). Especially with very young children who function most effectively with concrete terms and situations (Harter and Pike, 1984), assessing self-efficacy of specific aspects of tasks might yield the most reliable and valid information. However, while a few studies have demonstrated relationships between self-efficacy and math interest in adults

(Rottinghaus, Larson, & Brogen, 2003) and older students (Pietsch, Walker, & Chapman, 2003), self-efficacy and interest have not been assessed with young children.

Nor has the relationship between self-efficacy and math achievement been assessed in young children. There has been empirical investigation of academic achievement and a similar, though more general construct, self-concept. Positive academic self-concept influences academic achievement through behaviors, decision-making and ambitions (see Marsh and Craven, 1997 for a review of the literature). Feeling positively about one's academic skills might lead to academic behaviors (such as persistence) that then influence academic outcomes (Marsh and Craven, 1997). Though there have been few investigations of self-concept in the preschool years, Marsh, Ellis and Craven (2002) demonstrated modest correlations between academic self-concept and achievement scores, and Alexander and Entwisle (1988) demonstrated that first and second graders showed differences between self-expectations and achievements.

Therefore, we need a greater understanding of the roles of math interest and of self-efficacy in the beginning of the skills attainment process. Deci (1992) argues that interest is in a purer form in young children and that studying this age group will increase our understanding of interest's specific role. Interest in older children and adults is combined with other motivational forces such as fear of evaluation and social comparison, which makes it difficult to identify factors or outcomes that are related solely to interest. Additionally, studying processes while skills are emerging increases the likelihood that negative cycles have not become entrenched (Ruble & Flett, 1988), children's interests have not become stable (Wigfield et al., 1997), and individual differences in numerical ability have not become magnified (Morrison, McMahon &

Williamson, 1993). Focusing on preschool children is important as intervention programs have demonstrated the powerful window that preschool provides (Campbell & Ramey, 1994; Reynolds, 1994). The "school readiness" movement, which focuses on the transition into kindergarten, has highlighted the importance of preparing children to be good learners (Boyer, 1991; U.S. Department of Education, 1991; Wentzel et al., 1990). The U.S. Department of Education (1991) describes prepared children as those who "explore their environment actively and approach tasks with enthusiasm" (p. 2), yet enthusiasm has been too little studied in this age group. Lastly, such an approach also encourages a focus on developing children's strengths rather than emphasizing only deficiencies.

In addition to a need for research on the relationship between math interest and skills development with preschool children, there needs to be a greater understanding of this relationship in low-income samples that are particularly at risk. In a special 1994 *Child Development* issue on children and poverty, Huston, McLoyd and Garcia Coll highlight the need for increased research efforts on children in low SES environments. In their review, they describe work by Offord, Alder and Boyle (1986) who contend that low SES is the greatest contributor to school failure and disinterest. Though the connection between poverty, poor cognitive development and school failure is clear (Jordan, Huttenlocher, & Levine, 1992; Offord et al., 1986; Carta, 1992), understanding of the processes that drive the relationship is limited (Campbell & Ramey, 1994). A recent analysis of the National Assessment of Educational Progress (NAEP) data regarding high school students indicated that low-income status and motivational variables, along with exposure to learning opportunities, accounted for 45-50% of variance in mathematics proficiency (Byrnes, 2003). Studies with young low-income children suggest the impact of attitudes begins early in the schooling process. Stipek and Ryan (1997) demonstrated that cognitive skills of disadvantaged preschoolers, mostly Latino and African-American, were more influenced by motivational variables than were their advantaged, predominantly white counterparts. Reynolds (1989) found that measures of liking school were related to math learning at first grade in urban, low-income kindergartners. Understanding the early effects of math interest on achievement is especially important in disadvantaged populations who struggle against a variety of societal obstacles (Carta, 1992).

The existing math interest literature is also weak in clarifying the early stages of interactions of gender with interest and ability. Empirical work seeking to explain the disparity between women and men who pursue careers in mathematics and science has indicated that there is no significant difference between the genders in mathematical ability (Hyde et al., 1990). Therefore, it seems likely that motivational factors might be involved. With respect to specific math interest in high-school, college, and adulthood, males report more interest, and females show less confidence and less positive attitudes toward math (Hyde et al., 1990; Jackson, Fleury, Girvin, & Gerard, 1995; Nosek, Banaji, & Greenwald, 2002; Stevenson & Newman, 1986; White, 1999). At the same time, women show a stronger relationship between interest in math and career choice (Post, Stewart, & Smith, 1991). Similarly, the interestingness of the learning environment seems to be generally more important for females than males (Mitchell & Gilson, 1997). These findings suggest that understanding and fostering math interest might help narrow the gender gap in math achievement. It is unclear at what age these gender differences begin to develop. Jensen & McMullen (1995) found that 5th grade children showed no differences in interest in math and science careers, but 6th grade girls expressed less interest. However, other researchers have found differences in self-perception and values in children as young as first grade (Eccles, 1993; Measelle, Ablow, Cowan, & Cowan, 1998). Though no studies have investigated gender differences in math interest in preschool, studies do suggest that some types of differences in interest are present by this age. For example, Renninger (1992) found that preschool girls demonstrate stronger affect regarding objects of interest than preschool boys demonstrate. In sum, the nature, onset and effects of gender differences in early math interest remain unclear.

Additionally, the measurement of academic interest is an area sorely in need of refinement (Mitchell, 1993). Assessment of interest in older children or adults usually entails a self-report survey about a student's enjoyment of an academic subject (Campbell & Hackett, 1986; Lopez, Lent, Brown, & Gore, 1997; Mitchell, 1993), but this approach has not been applied to math interest in younger children. Observational measures have shown some promise (Lonigan et al., 1994; Ortiz, 1997; Ortiz, Stowe & Arnold, 2001), but have not been widely used, and teacher reports also have demonstrated utility in related areas (Normandeau & Guay, 1998; Reynolds, 1989; Wigfield et al., 1997), but have not been explored in relation to math with young children.

Since there is currently no standardized or accepted method to assess math interest in young children, conclusions based on any one method of assessment will be limited. For example, self-report methods might directly tap into interest, but be limited by preschool children's ability to express themselves; teachers might understand the concept of interest, but not be entirely accurate about children's interest levels given the lack of formal math instruction and assessment at this age. Though observational measures are more objective, the amount of observation which can be conducted is restricted by practical constraints, and does not directly provide information about children's inner emotional state. Thus, a multi-method assessment approach is critical to measuring interest, to better understanding the effectiveness of different measures, and to evaluating the relationship of math interest and mathematics ability. Lastly, much of the previous research on math interest and achievement has been cross-sectional. The lack of longitudinal studies makes it difficult to assess the direction of causality and a possible reciprocal nature to the relationship. Researchers have called for studies that examine whether interest predicts future academic achievement (Schiefele et al., 1992). Mitchell and Gilson (1997) state that previous interest research has been limited by the lack of data on changes in math interest, and they propose that changes in interest might predict changes in math achievement.

The current study investigated the relationship between math interest and ability in preschool children. Math interest has received little research attention in general, but no studies to date have specifically examined the construct with preschoolers. This study can provide information about the role of interest at the beginning of the attainment process and perhaps inform intervention and general teaching practices. Learning more about this relationship prior to formal schooling can provide information that is relatively free of confounding factors such as grades, test anxiety, and general school disaffection. Examining the unfolding of interest and skills across time may also provide clues about the causal role of math interest in academic achievement and the role of math ability on later math-oriented interests. By studying children at an early age and by using a longitudinal approach, this study helps to address this gap in the literature.

This project utilized a multi-method approach of interest measures and informants. In addition to providing information regarding which methods of assessing interest are the strongest, a multi-modal approach can provide converging evidence and strengthen project results. Another assessment aim was to provide further information about children's math interest in a more naturalistic setting. As few studies have investigated young children's interest while they were directly engaged in relevant activities, (Lonigan et al., 1994; Ortiz, 1997; Ortiz et al., 2001; Perry, 1998; Renninger, 1992), the observational component of this study can provide information regarding children's in vivo interest behavior.

Lastly, the present project involved a low-income, diverse group of children, a group particularly vulnerable to poor skill development. Understanding factors contributing to math achievement in this population is especially important, yet these factors are traditionally understudied. Additionally, differences in math interest as a function of gender have not been examined in this age group. This study aimed to provide a preliminary examination of possible early gender differences in math interest.

The current study investigated different measures of math interest, four specific hypotheses regarding the relationship between early math interest and mathematical skills and several other exploratory analyses. The psychometric properties and interrelationships of different measures of math interest were first explored to assess the measurement of interest and determine variables for later analyses. In terms of the first hypothesis, it was expected that early math interest would predict concurrent math skills at Time 1, as demonstrated in math research with older children and reading research with preschoolers. Second, it was hypothesized that early math ability would predict math interest at a later assessment above and beyond what can be predicted from initial skill level. Third, it was similarly hypothesized that early math interest would predict math skills at a later assessment, consistent with the proposed reciprocal relationship between interest and ability. Fourth, self-efficacy would be related to both math interest and math skill. The relationship between gender and math interest was evaluated as a preliminary examination, and gender differences in the relationship between interest and math ability were also examined as a possible moderating variable. Though there is little past research to suggest ethnic differences within a low-income sample, exploratory analyses were run regarding the relationship between ethnicity and different measurements of interest. Additionally, simultaneous to this study, a mathematics intervention was conducted with the same subjects, though results of that project will not be examined here.

CHAPTER 2

METHOD

Participants

One hundred and eighteen children (66 girls) from eight classrooms at two different Head Start Centers in Springfield, MA participated in this study. Ages at pretest ranged from 3.09 (37.10 months) to 5.41 years (64.99 months), with an average of 4.39 years (52.75 months) and a standard deviation of .63 (7.67 months). The sample consisted of 49 Hispanic (predominantly Puerto Rican), 44 African American, 11 Caucasian, 6 Asian (3 Chinese and 3 Vietnamese), and 8 biracial (7 African-Anglo American, 1 African American-Puerto Rican) children. Participating families were low-income (median earnings of $12,807), as Head Start income eligibility requirements are set at the official federal poverty line. Additionally, approximately 20% of the sample spoke English as their second language.

Procedure

Children were assessed on all measures in the winter (Time 1) and the spring (Time 2) with half of the classrooms receiving a mathematics intervention following Time 1. Standardized testing, behavioral assessment and child self-report were administered in two sessions, lasting between 20-30 minutes per session. Note was made if children were unable to complete an assessment because of English language fluency. Teachers completed three surveys about children's math interest, for which they were paid $15 per hour.

Classrooms were matched for criteria such as morning-versus-afternoon sessions and then randomly assigned to intervention or control condition. Targeted skills included number recognition, counting, one to one correspondence, comparison and understanding quantity. Children in the intervention group showed gains in math ability between Time 1 and Time 2, improving significantly more than the control group (Arnold, Fisher, Doctoroff, & Dobbs, 2002).

Measures

Assessment of Math Interest

Quasi-naturalistic observation. A quasi-naturalistic task of children's play with educational math activities was used to assess in vivo math interest. Past studies of academic interest in preschoolers have videotaped children engaged in subject-related activities and then coded their level of interest (Lonigan et al., 1994; Ortiz, 1997; Ortiz et al., 2001). Children were videotaped playing with three educational math games: (1) manipulatives for counting and sorting sizes, (2) felt numbers and mathematical symbols, and (3) a game to match cards with pictures of objects to cards with numbers corresponding to the amount of objects. For each activity, the experimenter introduced the materials to the child by demonstrating a math-oriented approach to the activity. The child was then told that he or she could play while the experimenter "worked" somewhere else in the room. Each task was concluded when the child either (1) said they were finished, (2) stopped playing with the toys or (3) 10 minutes was reached. (See Appendix 1 for protocol).

Observational ratings of interest. Children's behavior during the math tasks was coded in two ways (1) global codes evaluating the child's overall levels of Enjoyment (amount of focus and attention, as well as affect during tasks) and Goal-Directed Behavior (amount of structure, sophistication and persistence in their play), both on scales from 1 to 7, and (2) amount of time the child was on-task (Total Time Played). Each tape was coded by two undergraduate research assistants who were blind to group assignments. Average intraclass Correlations (ICCs) across the three tasks were .87 for Global Enjoyment (range .86 - .87), .84 for Global Goal-Directed Behavior (range .78 - .88) and .99 (all .99) for Total Time Played.

Child self-report regarding quasi-naturalistic assessment. After the activities of the quasi-naturalistic measure concluded, the children reported on their interest in each activity with the Children's Math Interest Self-Report (CMIS). This scale was modeled closely after the Young Children's Feelings about School (FAS) scale created by Stipek, Feiler, Daniels, & Milburn (1995) because of its good psychometric properties. After the math activities, children were trained to indicate their levels of enjoyment with practice items, and then asked to rate their "liking" of each task verbally and by pointing to one of five faces that ranged from big frowns to big smiles. In 30 pretest cases, children did not understand the procedure after training, so their data was not included in analyses.

Child report of general math interest. To assess more general interest in math activities, children were shown pictures of seven items found in their classroom, such as math manipulatives, books, puzzles and housekeeping activities. Children were told "Let's pretend it's free play time in class. Here are the things you can pick to do. Which one do you want to do?" Each chosen picture was removed, and the child was told to choose another picture until all of the pictures were assessed. Children's rank order of these objects was recorded as a measure of their interest in math activities in comparison to other activities.

During administration of this task, the validity of the measure was questionable, as children seemed to respond more strongly to photographs that they believed had been taken in their own classrooms and photographs that contained characters that they favored, regardless of the activity the character represented (such as expressing interest in a puzzle of the character "Clifford" because they liked Clifford rather than wanting to complete puzzles). Thus, the decision was made not to include this measure; poor test-retest reliability and the absence of any significant relationships with Time 1 variables suggest that this decision was reasonable.

Teacher assessment of child interest. Teachers completed two brief scales regarding each child's interest in math. The first scale, the Relative Interest Survey (RIS) is based on the Brief Reading Interest Scale which has been used to assess reading interest in preschool children (Ortiz, 1997). It has demonstrated strong reliability and modest validity with behavioral videotaped measures. Though it was originally used with parents regarding reading activities, it was modified for this study to be used with teachers regarding math activities. School-oriented activities that preschoolers might enjoy were listed and teachers rank ordered the options with 1 being the activity the child most preferred. This measure was then recoded so that higher levels of math interest are represented by larger numbers, with "Numbers/manipulatives" as the item of interest used for analyses. (See Appendix 2)

The second scale, the Level of Interest Survey (LIS), is a seven-point Likert scale designed as a brief global rating of children's general interest in math activities. (See Appendix 3.) The seven item scale measures children's interest in math overall and specific math related activities such as counting. Previous research has demonstrated that teachers are able to identify motivational orientations of preschool children and that these ratings were predictive of reading ability (Salonen, Lepola, & Niemi, 1998).

Lastly, a classroom ranking scale (Ranking) was introduced to address possible floor or ceiling effects in the two previous measures. Teachers were asked to rank order each child in the class as to who demonstrates the most interest to the least interest in math activities. Ratings were standardized by classroom to reduce between classroom effects, and the scale was recoded so that children who were more interested in math were represented by higher numbers.

Assessment of Self-Efficacy

Child self-report. Assessment of self-efficacy, Children's Math Self-Efficacy (CMSE) also involved modifying the Young Children's Feelings about School (FAS) (Stipek et al., 1995). Following the same procedure as described for the CMIS, children were asked to report how good they were at each of the tasks with which they had just played. Rather than using faces to anchor points on the 1 to 5 scale, children pointed to a simple graph with lines of increasing length to demonstrate their answer. During pretest, 32 children did not understand the procedure, so their data were not included in analyses.

Assessment of Mathematic Ability

Test of Early Mathematical Abilities (Second Edition: TEMA-2). Children's math ability was assessed using the TEMA-2 (Ginsburg & Baroody, 1990). This instrument measures relative magnitude, counting, conservation, and number identification for the preschool age group. It was chosen because it has good psychometric properties and has a wide range of items at the early stages of math development. Test-retest reliability is .94 for the measure overall and was .95 for the and Baroody have demonstrated the TEMA's validity in both its relation to other standardized measures, and its ability to identify children who are struggling in math.

CHAPTER 3

RESULTS

Analytic Plan

All 118 children were studied in cross-sectional analyses and analyses predicting skills and interest across time. The 55 children in the control group were utilized to assess test-retest reliability for the different measures. To determine which math interest variables should be used in analyses, reliability and intercorrelations with other interest variables were assessed. Variables with poor psychometric properties were dropped from further analyses. Exploratory analyses assessed the relationship of gender and of ethnicity with math interest variables and math skills.

To evaluate the hypothesis that interest predicts concurrent math skills, correlations were run between math skills and interest at Time 1. Regressions were then run with age and gender as control variables. Finally, the concurrent relationship was assessed again with gender*interest interactions included as possible moderating variables.

In terms of longitudinal relationships, Time 2 interest was regressed on initial skills and initial interest, controlling for gender, intervention, and any significant gender*interest interactions, to evaluate the hypothesis that early skills will predict later interest. To evaluate the prediction that early interest will predict later skills, Time 2 skills were regressed on initial skills, initial interest and the intervention with any significant gender*interest interactions included as moderators. Gender alone was not included in these analyses, as it was not anticipated that gender would predict skills. The above analyses were also planned for self-efficacy, though they were not carried out due to the variable's poor psychometric properties.

Descriptive Statistics

Math Interest and Self-Efficacy Variables

Table 1 presents Time 1 descriptive information for all variables under consideration. The variables discussed are those that were ultimately chosen for analyses. Means for Task 3 Global Enjoyment, Task 3 Global Goal-Directed, and Task 3 Total Time Played were 3.63 out of 7 (SD = 1.61), 3.03 out of 7 (SD = 1.89) and 150.47 out of 600 seconds (SD = 105.34) respectively. For child interest self-report, children reported high levels of liking the Task 3 activity (CMIS M = 4.35 out of 5, SD = 1.08). For teacher-rated interest, the LIS Composite mean indicated moderate levels of enjoyment (4.39 out of 7, SD = 1.21) and the RIS mean (5.56 with 10 being most preferred, SD=1.90) suggested math activities generally fell in the middle of children's preferred activities. Children expressed high levels of self-efficacy regarding their Task 3 performance (4.58 out of 5, SD = 1.01).

Math Skills

The mean raw score for the TEMA-2 was 7.59, which is equivalent to a scaled score of 88.65. Raw scores were used for analyses throughout this study, as the age groupings for the TEMA-2 standard scores are overly broad, considering together, for example, a child of 3 years, 1 month and 3 years, 11 months of age.

Measurement of Math Interest

As one intent of the current study was to further the development of math interest measurement, reliability and validity were assessed for each interest variable under consideration.

Observational Measures

Task 3 was the most mathematical of the three tasks and appeared to best capture children's behavior during math-oriented play. Informal observation during administration suggested that children with low numerical awareness quickly disengaged from the task, while more proficient children became engrossed. Reliability and validity data are consistent with this impression. Test-retest correlations for the control group for each task (Table 2) indicate that Task 3 assessments were more stable over time than the same variables for Task 1 and Task 2. As seen in Table 3, Total Time Played for Tasks 1 and 2 were not significantly related to any of the selected teacher variables, nor was Task 2 Global Enjoyment, while all Task 3 variables were significantly related to most teacher variables. Therefore, Task 3 variables were chosen for analyses. These variables were highly interrelated (Global Enjoyment/Global Goal Directed .69, Global Enjoyment/Total Time Played .73, Global Goal Directed/Total Time Played .61), suggesting that there was overlap in the constructs they measured.

Children's Math Interest Self-Report (CMIS)

As items from Task 3 of the Behavioral Assessment were chosen for analysis, children's self-report about enjoyment of Task 3 was also used. Test-retest reliability was not significant for the CMIS (Table 2), indicating that children were not consistent in their reports over time. The CMIS was moderately correlated with Task 3 Global Enjoyment (Table 3), indicating that children who reported liking the task displayed higher levels of enjoyment during the quasi-naturalistic assessment, but not correlated with teacher measures (Table 4). Though this measure did not demonstrate reliability, its relationship with the observational measure suggests possible validity; given that this measure is the only available assessment of self-reported interest, it was retained, though results with this measure should be interpreted with caution.

Teacher Measures

Table 2 provides test-retest correlations and Table 4 provides intercorrelations between teacher variables under consideration. RIS demonstrated modest test-retest reliability and was modestly correlated with other teacher variables. Teacher Ranking was relatively consistent over time, with strong correlations with all LIS variables aside from Likes Puzzles.

All variables from the LIS demonstrated consistency across time, with Likes Math, Likes Numbers and Likes Counting as the most reliable. These three variables were also the most highly correlated with the RIS and Ranking measures, as well as with one another. Therefore, these variables were averaged together to create a LIS Composite to be used for assessing concurrent relationship with the TEMA. The other LIS variables were dropped from further analyses.

Additionally, in order to reduce error variance and provide a more powerful measure of interest to use for predictive analyses, an overall teacher composite variable was created. The RIS and LIS composite were each standardized and then averaged with the Ranking ratings. The composite had acceptable reliability between initial measures (Table 2), with a pretest coefficient alpha of .92 and Test-Retest of .73.

Children's Math Self-Efficacy (CMSE)

As per self-reported interest, only children's self-report about efficacy at Task 3 was used. As seen in Tables 2 through 4 the self-efficacy measure was not reliable over time, nor did it correlate with any selected measurements of interest. Additionally, as described earlier, many children did not demonstrate understanding of the measure. For these reasons, self-efficacy was not included in further analyses.

Gender Differences in Math Interest and Skills

Boys and girls were not significantly different on any of the observational variables or the self-report interest measure (all p values > .33). While the Teacher Composite variable, the RIS, and the Ranking measure did not indicate teacher-rated differences between boys and girls, the LIS Composite indicated gender differences in interest with girls rated as more interested in math activities than boys (4.78, SD = 1.21 and 4.21, SD = 1.18), $t(116) = 2.75$, $p < .001$. Boys and girls did not demonstrate significantly different levels of math ability.

Ethnicity in Measuring Math Interest and Skills

Interest variables. Because there were so few children in each group, neither Asian, White or Biracial children were included in analyses specific to ethnicity. Neither observational nor self-reported interest (CMIS) indicated ethnic differences between African-American and Hispanic children. In terms of teacher measures, the Ranking measure indicated that African American children preferred math activities more than Hispanic children (.20, SD = .98 and -.21, SD = .87), $t(88) = 2.14$, $p < .04$, though the Overall Teacher Composite, LIS Composite and RIS did not indicate ethnic differences.

Math skills. In terms of skills, African American children's TEMA-2 scores tended to be higher than Hispanic children's TEMA-2 scores (8.13 and 6.03), $t(86) = 1.78$, $p < .08$. However, while the Hispanic children who were unable to understand the initial portions of the TEMA-2 were not included in analyses, it is possible that English fluency might have affected scores for some of the remaining children.

Concurrent Relationship between Interest and Skills

Results pertaining to a central hypothesis in this study, the concurrent relationship between skills and interest at Time 1, are presented in Table 5. The TEMA-2 was moderately to strongly correlated with all observational and teacher-rated measures of interest. Child interest self-report was not significantly related to ability.

For each correlation between interest variable and TEMA-2, gender and age were added as control variables (Table 5). Though the Beta weights were somewhat reduced when the control variables were added, all relationships remained significant. Gender*interest interactions were run for each variable of interest to assess for interactions between the skills and interest relationships. There were no significant gender*interest interactions with all p values greater than .18, so the interaction variable was not included in further analyses.

Prediction of Later Interest from Initial Skills

It was hypothesized that initial TEMA-2 scores would predict later levels of math interest. Multiple regressions were run, with Time 2 interest variables being regressed on initial skills and initial interest, with gender and the intervention included as control variables. For all variables of observed interest, children's initial ability level predicted their level of interest in the math task (Global Enjoyment, $\beta = .27$, $p < .001$; Global Goal-

Directed, $ß = .34$, $p < .001$, Total Time Played, $ß = .29$, $p < .001$). Neither self-report ($ß = .13$, $p = .24$) nor Teacher Composite ($ß = .10$, $p = .24$) were significantly predicted by initial skill level, though both relationships were in the predicted direction.

Prediction of Later Skills from Initial Interest

In a similar approach, multiple regressions were run to assess whether interest at Time 1 predicted skill at Time 2, with the intervention included as a control variable. While initial Global Enjoyment and Global Goal-Directed were predictive of later mathematical skill (Global Enjoyment, $ß = .13$, $p < .001$; Global Goal-Directed, $ß = .23$, $p < .001$), Total Time played was not significant ($ß = .07$, $p = .13$). Self-reported interest at Time 1 did not predict later skills ($ß = .02$, $p = .71$). The composite variable for teacher-reported interest was predictive of later skills ($ß =.17$, $p < .001$).

CHAPTER 4

DISCUSSION

This study extends the existing literature on interest and academic ability by investigating the psychometric properties of interest measurement and demonstrating a relationship between math interest and math skills as early as preschool. In addition to a concurrent interest-skills relationship, longitudinal results provide some support for a cyclical relationship in the development of math interest and math skills over time.

To date, there has been little empirical attention to the measurement of interest, especially in young children. Results of this study suggest that observational measures and teacher-rated interest can demonstrate both stability over time and moderate agreement between informants, furthering progress in the measurement of math interest in this age group. Self-reported interest was not stable across time, but was modestly related to observed enjoyment.

Results for observational measures suggest that interest can be reliably perceived by objective informants when assessing children's level of sophistication, focus and pleasure during a mathematical task. Additionally, it seems that a brief, quasi-naturalistic assessment can effectively capture elements of children's interest in math. Previously defined characteristics of interest such as enjoyment and focused attention, structure and persistence, and on-task behavior, seemed to be successfully operationalized by "Global Enjoyment", "Global Goal-Directed", and "Total Time Played." Global Goal-Directed demonstrated the most stability and highest correlations with teacher measures, while Total Time Played demonstrated the weakest. This suggests that persistence and a sophisticated approach to the task might be critical components of interest, while the amount of time devoted to the task might be a less important measurement. The strength of goal-directed behavior is consistent with studies identifying the importance of persistence in reading skill development (Ainley, Hidi, & Berndorff, 2002) and might be similar to the "focused attention" that Ruff and Capazzoli (2003) hypothesized makes young children less vulnerable to distraction, thereby increasing exposure to learning opportunities. However, as these variables are derived from children's behavior during a brief and isolated experience, generalizations about the differences between them must be interpreted with caution.

While all three teacher measures demonstrated acceptable psychometric properties, the RIS measure was consistently weaker than the other two measures. The LIS showed a stronger relationship with Global Enjoyment than the Ranking measure demonstrated, but not with the other measurements of observational interest. Findings suggest that assessing teacher-rated interest through prioritizing preferred activities was less successful than an approach with higher face validity (LIS) or comparing children to one another (Ranking). Modest correlations existed between teacher and observational measures, suggesting that both were capturing a component of children's experience of math activities. It is not surprising that these measures did not correspond more strongly to one another, as teachers were assessing children's general behavior, while coders were assessing behavior during a specific task. In terms of interest self-report, the CMIS demonstrated neither stability over time nor relationships with any teacher measured interest. Its relationship with Global Enjoyment suggests that children might be able to accurately report their liking of math activities, but, as this is the only significant relationship with the CMIS, it must be interpreted with caution. Many children in the sample had significant difficulties understanding the CMIS measure. This might be due to developmental limitations in preschoolers in understanding or reporting on the interest construct, but is likely a function of the fact that approximately 1/5 of the sample spoke English as their second language, and they had particular difficulty understanding the scale. Therefore, it would be premature to conclude that children's self-report can not accurately reflect their interest or relate to other measures. Additionally, though the assessment of self-reported general math interest through photographs was not successful in this study, further investigation with more standardized measures might yield positive results.

Similarly, results regarding self-efficacy are inconclusive because of measurement difficulties. As children predominantly reported very high levels of self-efficacy, ceiling effects might have also contributed to the lack of findings for this measure. However, since this study was conducted, a new scale (Marsh et al., 2002), the Self Description Questionnaire for Preschoolers (SDQP), has demonstrated that 4- and 5-year olds can reliably report on various aspects of self-concept, including math. Additionally, the authors found relationships between self-concept and academic achievement at this age, though they found little distinction between verbal and mathematic self-concept. Such results suggest that refinements in the measurement of self-concept with young children might allow for future investigations of self-efficacy and math interest as well.

Analyses of the relationship between concurrent interest and skill indicate that, even at the emergent stages of skill development, children who are farther in their math development are more likely to be engaged during math activities. These results are consistent with results reported by other researchers (Byrnes, 2003; Köhler et al., 2001) and extend the findings to preschool children. Additionally, study results are actually somewhat stronger than the average correlation coefficient of .31 found in a meta-analysis of 121 older samples (Schiefele et al., 1992). This might indicate measurement differences (as many of these previous studies assessed interest through self-report) or perhaps a stronger relationship at the nascent stages of skill development. Regardless, findings indicate that motivational factors such as interest already exist in very young children who have had little formal exposure to math instruction. Global Goal-Oriented was again the most significant observational math interest measure, while the LIS composite was the most related of the teacher measures. These results continue to suggest that these measures might be the most successful of the included methods of assessing interest.

In addition to the concurrent relationship, longitudinal findings are consistent with the hypothesized causal models of the relationships between interest and ability and aforementioned studies with older children (Köhler et al., 2001; Schiefele & Czikszentmihalyi, 1995; Singh, et al., 2002). In these models, children who are initially more interested in math will more readily develop math skills, through increased time spent in math activities, increased levels of arousal, deeper cognitive processing or mechanisms not yet identified. Similarly, children with strong skills will continue to increase their engagement over time, possibly due to the pleasure resulting from doing something well. Analyses of children in this study found consistent support for the hypothesis that interest leads to greater skill development, as the Teacher Composite and Global Enjoyment and Goal Directed in the beginning of the study all predicted math skill at a later assessment. The converging evidence provided by teacher and observational variables increases the credibility of these findings. Predictions in the other direction, that children who were more skilled demonstrated more interest in math activities at a later date were supported by all observational variables, but not by teacher report. It is unclear why teacher report and Total Time Played were each predictive in one relationship but not the other, and as such, should be replicated. However, the consistency of Global Enjoyment and Global Goal Directed in both directions suggests the strength of these variables in assessing children's interest. While the effect sizes of the significant relationships are modest, they are still notable as initial levels were being controlled for and the length of time between assessments was brief.

These longitudinal findings give further credence to prior studies demonstrating increasing strength between interest and ability over time (Reynolds, 1989; Wigfield et al., 1997) and to researchers who hypothesize that math and interest engage in a reciprocal relationship where children becomes increasingly (or decreasingly) engaged in and proficient in math activities (Ma, 1997). This finding is in contrast to Onatsu-Arvilommi & Nurmi (2000), who found that first grade children with less skill were more likely to avoid math activities, but found no relationship for engagement predicting skills. While previous studies have also found that interest predicts skill, it is possible that the reciprocal relationship is more pronounced at a very young age, and becomes weaker as skill becomes more stable over time.

Unlike results for older children, findings regarding gender in this sample suggest few differences in interest. No measures demonstrated gender interactions in the relationship between interest and ability. On one measure, the LIS composite, teachers rated girls as more interested than boys in general enjoyment in math. While this difference was not supported in observational measures, contextual differences in these instruments limit comparisons; i.e. it is possible that girls were not more engaged during the quasi-naturalistic task than boys, but that they do evidence more overall interest in math. Additionally, this finding relates somewhat to a previous study that found preschool girls demonstrated more affect while playing with preferred toys than their male peers (Renninger, 1992). An alternate interpretation is that results represent teacher stereotypes, rather than objective differences, especially as the LIS is the teacher measure with the most face validity. However, since teachers only rated girls and boys differently on one measure, interpretation is speculative and results should be replicated. Regardless, the teacher ratings of girls as more rather than less interested and the scarcity of other gender differences in this sample suggests that the math "gender gap" that has been reported in adolescents and adults may develop subsequent to the preschool years.

Though there has been little prior investigation regarding ethnic differences in interest, exploratory analyses in this sample found differences between African-American and Hispanic children on one measure of teacher-rated interest. Teachers ranked African-American children more highly than Hispanic children in preferring math activities. Though the trend indicating higher math skills for African-American children is consistent with this finding, disparities in English proficiency caution that this might be due to language rather than ethnic difference. Additionally, similarly to gender analyses, there is a lack of converging evidence for this finding, as it was present in only one measure. Characteristics of this sample, including language issues and small numbers of Caucasian and Asian children, limit extrapolations that can be made about ethnic differences in math interest without replication. Further investigation is necessary for both gender and ethnicity findings to assess whether ratings reflect real differences or result from either teacher stereotypes or sample characteristics.

As with the few other studies assessing motivational factors in low-income children (Byrnes, 2003; Reynolds, 1989; Stipek & Ryan, 1997), findings indicate a relationship between math interest and ability. While there is no middle or high income comparison group for this sample in regards to interest, these children fell approximately one standard deviation below norms in terms of math ability. These results, together with findings from the aforementioned studies indicating increased sensitivity to motivational factors and the dearth of low-income group members pursuing technology careers, emphasize the importance of fostering math interest in this population. These findings could be further strengthened by future studies including a range of socio-economic groups to investigate if low-income children are more vulnerable than their higher SES peers.

As this study investigated interest in a Head Start population, results cannot be generalized to children with significantly different demographic characteristics. Though the global observational variables appear to be the most robust measure of interest and moderately correlated with teacher measurement, the assessment was somewhat novel for the children and might not represent their natural, daily behavior. Future work should compare such quasi-naturalistic assessments with in-classroom observations over time. Additionally, as only math skills and math interest were measured, it is not clear if the significant relationships are subject-specific to math or representative of more general cognitive ability and motivational constructs: it is possible that children who are more skilled overall have a more general interest in learning. Likewise, the level of analysis of this study can not reveal the underlying mechanisms driving the relationships between interest and skill level.

Future studies should continue the development of math interest measures, perhaps with the intent of creating standardized variables within naturalistic settings and determining the best methods to assess the different components of interest. Such investigation could provide insight into the underlying mechanisms, such as processing or level of arousal, with which interest and skill interact with one another. Additionally, a more elaborate, longer-term longitudinal study could assess effects of the preschool relationships between interest and ability into formal schooling, as well as investigate the development of gender differences in interest. As previous work has demonstrated that skills-focused interventions can also affect interest (Arnold et al., 2002; Morrow & Young, 1997; Weber, Martin, & Patterson, 2001), future studies could further assess causal mechanisms by investigating the impact of both skills- and interest-focused interventions over time.

In terms of factors that lead to the development of interest, previous work indicates that teacher behavior can relate to both math interest and skill attainment (Mitchell, 1997; Valas & Sovik, 1993), and future assessment of classroom contexts for young children could indicate pedagogical influences on interest. Additionally, parents' beliefs about their children's math ability have shown to relate to attitudes toward school and math achievement in kindergarteners (Galper, Wigfield, & Seefeldt, 1997) and to math achievement in first graders (Aunola, Nurmi, Lerkkanen, & Rasku-Puttonen, 2003). Studies with reading have indicated that parents' report regarding their children's interest in reading was related to children's ability (Baker & Scher, 2002; Morrow & Young, 1997), as well as finding a relationship between parents' pleasure in reading and their children's ability (Baker & Scher, 2002). Including parent report in future studies could provide further information about math interest measurement and elucidate parental role in children's development of math interest. Similarly, though this study has been the only one to date to look at math interest in preschoolers, results suggest that the cyclical relationship between skills and interest has already begun. As prior studies of reading interest have found relationships between interest and skill in children as young as 20 months (Crain-Thoreson & Dale, 1992), similar investigations of toddlers should be undertaken with math to attempt to identify what constitutes math interest prior to any formal skill attainment and investigate relationships between interest and later skills.

The existence of relationships between math interest and emergent math skills is both encouraging and concerning. This study provides empirical support for those emphasizing the importance of these processes in the early stages and the role of interest in the development of math ability. As preschool is a period where learning is relatively free of confounds such as grades, overt peer pressure and school refusal, interest is perhaps more open to interventions that could have lasting effects on skills attainment. Additionally, catching children early, before they experience multiple frustrations and negative attitudes due to lack of skills (Smiley & Dweck, 1994; Wigfield et al., 1997) could make a significant impact on the motivational problems associated with later math disenfranchisement. On the other hand, these results indicate that the cycle between skills and interest may have already begun prior to any formal schooling, and the children with low ability are already becoming disinterested in math. This suggests that many children, especially those not attending preschool programs, might be losing interest in math before beginning formal instruction. However, findings also point to the potential benefits of early childhood and kindergarten curriculums focusing on the development of interest alongside the development of skills, towards decreasing negative cycles and facilitating positive ones.

Table 1

Means and Standard Deviations at Time 1

Variable	M	SD
Child Skills		
TEMA-2 scores	7.59	6.16
Child Interest		
Observational		
Task 1 Global Enjoyment[a]	3.59	1.45
Task 2 Global Enjoyment[a]	3.99	1.60
Task 3 Global Enjoyment[a]	3.63	1.61
Task 1 Global Goal-Directed[a]	4.10	1.90
Task 2 Global Goal-Directed[a]	3.35	1.66
Task 3 Global Goal-Directed[a]	3.03	1.90
Task 1 Total Time Played[b]	161.70	125.03
Task 2 Total Time Played[b]	190.34	134.29
Task 3 Total Time Played[b]	150.50	115.04
Self-Report		
CMIS Fun[d]	4.35	1.08
Teacher Scores		
RIS Number[c]	5.56	1.70
LIS Math[a]	4.39	1.21
LIS Number[a]	4.53	1.44
LIS Counting[a]	4.69	1.21
LIS Puzzle[a]	5.28	1.13
LIS Sorting[a]	5.16	1.13
LIS Composite[a]	4.53	1.23
Self-Efficacy		
CMSE[d]	4.58	1.01

[a] Scale ranged from 1 to 7
[b] Total Time possible 600 seconds
[c] Scale ranged from 1 to 10
[d] Scale ranged from 1 to 5

Table 2

Test-Retest Reliability of Interest Variables for Control Group

Variable	Reliability
Observational	
Task 1 Total Time Played	.34
Task 2 Total Time Played	.56
Task 3 Total Time Played	.51
Task 1 Global Enjoyment	.53
Task 2 Global Enjoyment	.51
Task 3 Global Enjoyment	.70
Task 1 Global Goal-Directed	.48
Task 2 Global Goal-Directed	.50
Task 3 Global Goal-Directed	.79
Self-Report	
Children's Math Interest Self-Report (CMIS)	.01
Children's Math Self-Efficacy (CMSE)	.01
Teacher Variables	
Relative Interest Survey (RIS)	.35
Classroom Ranking	.68
Level of Interest Survey (LIS)	
Likes Math	.69
Likes Numbers	.73
Likes Counting	.68
Likes Puzzles	.60
Likes Sorting	.50
Composite (Math, Numbers Counting)	.73
Overall Teacher Composite (RIS, LIS Composite, Ranking)	.73

Table 3

Correlations between Observational Variables and Other Interest Variables

Categories	Self-Report (CMIS)	RIS	LIS Likes Math	LIS Numbers	LIS Counting	LIS Puzzle	LIS Sorting	Ranking	Self-Efficacy (CMSE)
Task 1 Global Enjoyment	.15	.16	.33**	.41**	.37**	.13	.28**	.20**	.04
Task 2 Global Enjoyment	.01	.10	.16	.17	.10	.03	.16	.14	.05
Task 3 Global Enjoyment	.21*	.34**	.43**	.51**	.43**	.22*	.27**	.38**	.11
Task 1 Global Goal-Directed	.22*	.18	.39**	.47**	.39	.20*	.29**	.26**	.03
Task 2 Global Goal-Directed	.01	.15	.24*	.29**	.25**	.06	.12	.25**	.04
Task 3 Global Goal-Directed	.13	.38**	.54**	.56**	.48**	.11	.31**	.54**	.17
Task 1 Total Time Played	.03	.00	.12	.22*	.16	.02	.05	.06	.00
Task 2 Total Time Played	.02	.08	.12	.12	.09	.07	.11	.09	.11
Task 3 Total Time Played	.11	.24**	.29**	.34**	.26**	.11	.18	.29**	.01

*$p \leq .05$ **$p \leq .01$

Table 4

Intercorrelations between Interest Self-Report, Teacher-Rated Interest and Self-Efficacy Variables at Time 1

Categories	1	2	3	4	5	6	7	8	9
1. CMIS (Interest self-report)	--	.06	.09	.04	.00	.02	.03	.09	.00
2. RIS		--	.28**	.31**	.36**	.37**	.29**	.26**	.14
3. Ranking			--	.65**	.69**	.67**	.11	.59**	.11
4. LIS Likes Math				--	.88**	.82**	.37**	.70**	.08
5. LIS Likes Numbers					--	.89**	.41**	.63**	.10
6. LIS Likes Counting						--	.48**	.69**	.10
7. LIS Likes Puzzles							--	.48**	-.24*
8. LIS Likes Sorting								--	.01
9. CMSE (Self-efficacy)									--

$*p \leq .05$ $**p \leq .01$

Table 5

Relationships between TEMA-2 Scores and Interest at Time 1

Variable	r	ß (controlling for age and gender)
Global Enjoyment	.49**	.35**
Global Goal-Directed	.63**	.50**
Total Time Played	.39**	.24**
CMIS (Interest self-report)	.10	.03
Level of Interest Composite	.62**	.44**
Relative Interest Survey	.33**	.20**
Ranking	.55**	.38**

**$p \leq .01$

APPENDIX A

QUASI-NATURALISTIC MATH INTEREST PROTOCOL

Administer toys in this order:

Task 1 Farm Animals Manipulatives
Task 2 Felt Number Board
Task 3 Matching cards with pictures and numbers

"I have some toys here for you to play with. I will show you each toy and you can play with it by yourself. I have some work I need to do, so I can't play with you right now. I will sit right over here while you play. Are you ready to see the first toy?"
"Let me show you one way that kids play with this toy." Demonstrate toy.

Farm Animals
Some kids like to count the animals. Take each animal out and count to 3. Return the animals to the container.
Some kids like to make groups of colors. Take out 1 red animal and say "**Here's a red one**". Take out 1 blue animal and say "**Here's a blue one**". Take out 1 yellow animal and say "**Here's a yellow one**". Take out another red animal "**Red**". Take out another yellow animal "**yellow**" Take out another blue animal "**Blue.**" While circling the different grouping with your finger... "**All the yellow ones go together, all the red ones go together and all the blue ones go together**." Return the animals to the container. **So, you can count the toys, you can put them in groups of color or you can do whatever you want.**

Felt Numbers -
Some kids like to find the numbers. Pick 2 different numbers out of the pile and say the numbers out loud while putting them on the board. Take them off the board.
And they like to find the shapes. Pick out a square and a circle and say the names out loud while putting them on the board. **You can find the numbers, shapes or whatever you want to do.** Return all of the felt pieces to the bag.

Matching Game
Some of these cards have numbers and some have pictures of things. Pick up the card of the number 1 **Here is the number 1.** Pick up the card of the horse. **Here is a picture of one horse. There is 1 horse, 1. These cards go together.** (Put the 1 and the horse next to each other) **Here is the number 3.** (Pick up the card of the number 3) **Here are 3 kids. 1, 2, 3 ..3 kids. These cards go together.**

After each toy demonstration say, **When you are finished, put the toys away in this and tell me you are finished.** Make sure the container/box is near the child so that they can put the toys away when they are ready.

When the child begins to clean up, ask them "**Are you finished or do you want to keep playing with that toy?** If they are finished say "**Can I help you clean up or do you want to do it by yourself?"** If the child wants your help, follow their lead in the clean-up, as some of them continue to "play" while they are cleaning-up.

Additional Points

- If child asks for help with any of the toys while they are playing, repeat the demonstration, but do not give additional instructions. Reinforce that they can play with the toys in whatever way they want.

- If the child asks what something is, say "**What do you think it is**?" Reinforce whatever they say it is. If they ask you specifically "Is this a 3?" Tell them if it is or is not (whatever the right answer is).

- Begin timing after demonstration is finished. Allow child to play for toy for up to **10** minutes. Tell the child that it is time to play with the next toy if they are still playing at 10 minutes.

- If child does not play with the toys in a math-oriented way at all (i.e. they throw the toys around, move the toys aimlessly, do not seem to be paying attention, or strictly use dramatic play), allow him/her to continue for 1 minute, then say, **Are you ready for the next toy?**

- If the child begins to play in a math-oriented way, but within the **10** minutes, stops playing all together but does not clean up or announce that they are finished, wait 5 seconds and say

  Do you want to keep playing with this toy?
  If the child says no, help them clean up and move on to the next toy.
  If the child says yes, let them continue playing.
  If this happens a second time, repeat the procedure.

  If it happens a third time, say **Are you finished with this toy?** If they say no, allow them to continue until 10 minutes are up. Then say, **It's time for the next toy.**

- If child asks to play with him/her during the administration, **I can play with you for a little while after you finish playing with all of the toys. For now, please play by yourself.** Experimenter will then play for 1 minute with child after the entire task is over.

- If the child does not want to stop playing with an individual toy after experimenter says it is time to move on, say **We have a lot of toys to play with. You can play with it again at the end.** Then let him/her play with the toy of their choice at the end for 1 minute.

- Reinforce child after their play with each toy by saying **good job, etc**.

- If child wants to talk while s/he is playing with the toys (other then asking the experimenter to play), respond as simply as possibly to what the child says such as **uh-huh, I see, right, Oh, etc.** If the child asks you a question, respond as briefly as possible (preferably yes or no) and try to minimize eye contact.

APPENDIX B

RELATIVE INTEREST SURVEY

Please order this child's interest in the following activities from 1-10, with 1 being the activity which the child likes the most and 10 being the activity the child likes the least. It might be helpful to think of how likely the child is to choose each activity during free play time.

_____ Coloring

_____ Reading a book by him/herself

_____ Playing with a toy that involves sorting objects

_____ Playing with a ball

_____ Playing "pretend" or “make-believe”

_____ Playing with puzzles

_____ Circle Time

_____ Building things with blocks

_____ "Board games" with rules.

_____ Number/manipulatives activities

APPENDIX C

LEVEL OF MATH INTEREST SURVEY

Please circle the number that best describes this child's interest in math activities. 1 indicates the lowest amount of interest and 7 equals the highest amount of interest. Please compare this child to your idea of the "average" child of his or her age.

1. How much does this child seem to like math activities overall?

1	2	3	4	5	6	7
Not at All						One of Favorites

2. How much does this child seem to enjoy free play activities?

1	2	3	4	5	6	7
Not at All						Very Much

3. How interested does this child seem to be in learning about or demonstrating their knowledge of numbers?

1	2	3	4	5	6	7
Shows no interest in learning numbers						Very excited to learn numbers

4. How interested does this child seem to be in learning about or demonstrating their knowledge of letters?

1	2	3	4	5	6	7
Shows no interest in learning letters						Very excited to learn letters

5. How much does this child seem to enjoy counting activities?

1	2	3	4	5	6	7
Not at All						One of Favorites

6. How much does this child seem to enjoy activities such as puzzles?

1	2	3	4	5	6	7
Not at All						One of Favorites

7. How much does this child seem to enjoy activities that involve sorting or creating categories of objects?

1	2	3	4	5	6	7
Not at All						One of Favorites

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